

00R00085

METHOD AND DEVICE FOR CORRECTING LIGHTNESS OF IMAGE

## BACKGROUND OF THE INVENTION

## 1. FIELD OF THE INVENTION:

The present invention relates to a method for  
5 correcting lightness of an image, which provides a desired,  
optimum dynamic range to a digital still color picture  
that has been captured by a digital camera, a monitoring  
camera, etc.

## 10 2. DESCRIPTION OF THE RELATED ART:

As a method for correcting lightness information,  
color information, etc., of a digital still color image,  
a retinex method taking a retina of an eyeball as a model  
is proposed, in which a lightness value of an image with  
15 a biased dynamic range (dynamic characteristic) is  
corrected based on local information of the image. In  
such a retinex method, the quality of an image can be  
improved by correcting a low lightness value resulting in  
a darker portion in the image to a high lightness value,  
20 and a high lightness value resulting in a brighter portion  
in the image to a low lightness value.

As examples of such a retinex method, the single  
scale retinex method (Daniel J. Jobson, et al.,

"Properties and Performance of a Center/Surround Retinex," IEEE Trans. on Image Processing vol.6, pp.451-462, March 1997) and the multiscale retinex method (Daniel J. Jobson, et al., "A Multiscale Retinex for 5 Bridging the Gap Between Color Image and the Human Observation of Scenes," IEEE Trans. on Image Processing vol.6, pp.956-976, July 1997) are proposed.

In the single scale retinex method, a spectrum 10 component  $I_i(x,y)$  ( $i = 1, 2, \dots$ ) of a subject pixel  $I(x,y)$  in an original image is corrected by a surround function  $F(x,y)$  obtained from image information of the surround pixels. The result  $R_i$  of retinex processing is represented by expression (1):

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$$R_i = \log(I_i(x,y)) - \log[F(x,y) * I_i(x,y)] \quad \dots \quad (1)$$

where "\*" denotes a convolution operator.

20 In this case, the surround function  $F(x,y)$  is a function which is based on the image information of the surround pixels with respect to the subject pixel  $I(x,y)$ , which is represented by expression (2):

$$F(x,y) = K e^{-r^2/c^2} \quad \dots (2)$$

5 where  $r$  denotes a distance ( $r^2 = x^2 + y^2$ ) between the subject pixel and the surround pixel, and  $c$  is a scaling variable. Furthermore,  $K$  is a scalar coefficient, which is set so that  $\iint F(x,y) dx dy = 1$  is satisfied, i.e., the total value of the surround function is 1.

10 After the result  $R_i(x,y)$  of the single scale retinex processing has been obtained, the result  $R_i(x,y)$  is corrected with a gain correction value  $A_g$  and an offset correction value  $A_o$ , and extended to conform to an appropriate dynamic range. A result of the correction 15 retinex processing,  $I_{R_i}$ , is represented by expression (3):

$$I_{R_i} = A_g \times R_i + A_o \quad \dots (3)$$

20 As described above, in the single scale retinex method, the spectrum band components of the subject pixel are retinex-processed based on the surround function. On the other hand, in the color restoration multiscale retinex (MSR) method, each of the spectrum band

components,  $I_i$ , of the subject pixel is retinex-processed by  $N$  types of scales. In this case, the result of the single retinex process for each of the  $N$  scales is multiplied by a weighting factor  $\omega_n$ , and the multiscale results with respect to all the scales are totaled. The result of the multiscale retinex (MSR) processing,  $R_{MSRi}$ , is represented by expression (4):

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$$R_{MSRi} = \sum_{n=1}^N \omega_n R_{ni} \quad \dots \dots (4)$$

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The result of the MSR processing,  $R_{MSRi}$ , which has been obtained by expression (4), is then corrected with a color correction coefficient  $C_i(x,y)$  that is represented by expression (5):

$$C_i(x,y) = \beta \{ \log[\alpha I_i(x,y)] - \log \left[ \sum_{h=1}^S I_i(x,y) \right] \} \quad \dots \dots (5)$$

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The result of the MSR processing,  $R_{MSRi}$ , obtained by expression (4) is corrected by the color correction coefficient  $C_i(x,y)$  of expression (5), thereby obtaining the result of the color correction multiscale retinex processing,  $R_{MSRCRi}(x,y)$ , as shown in expression (6):

$$R_{MSRCR_i}(x,y) = C_i(x,y) \cdot R_{MSR_i}(x,y) \quad \dots \quad (6)$$

5 The result of the color correction multiscale  
retinex processing,  $R_{MSRCR_i}(x,y)$ , is corrected, as  
described as to the single scale retinex method, with the  
gain correction value  $A_g$  and the offset correction  
value  $A_o$  which are correction parameters, and extended  
to conform to an appropriate dynamic range. A result of  
10 the final color correction multiscale retinex  
processing,  $I_{MSRCR_i}$ , is represented by expression (7):

$$I_{MSRCR_i} = A_g \times R_{MSRCR_i} + A_o \quad \dots \quad (7)$$

15 In the color correction multiscale retinex method,  
an original image is generally single scale retinex  
processed with respect to three scales (small, medium,  
and large scales), whereby corrected images corresponding  
to the respective scales are obtained. These corrected  
20 images are synthesized to obtain an image with corrected  
lightness and color. In the small scale, a distance  
between a subject pixel and a surround pixel (the radius  
of the small scale) is relatively short, whereas in the  
large scale, a distance between a subject pixel and a

surround pixel (the radius of the large scale) is relatively long. In the medium scale, a distance between the subject pixel and a surround pixel (the radius of the medium scale) is set to a length intermediate between that 5 of the small scale and that of the large scale.

In each of the small, medium, and large scales, the scale size thereof is fixed, and is not an appropriate size for making a desirable correction. Accordingly, a 10 correction result widely varies in accordance with the size or color of an original image to be corrected, whereby a sufficient correction effect may not be obtained. Especially in the case where the size of an image is large, if the scale size of the small scale is fixed at a small 15 size, a noise may be generated in a corrected image.

Furthermore, the correction parameters shown in expression (7), i.e., the gain correction value  $A_g$  and the offset correction value  $A_o$ , are fixed values. With 20 such parameters, in some images, the lightness of pixels may not be corrected so as to conform to an appropriate dynamic range.

Thus, with the conventional color correction multiscale retinex method, sufficient flexibility in correcting images cannot be obtained, and some images may not be corrected appropriately. Therefore, the 5 conventional color correction multiscale retinex method is less than satisfactory as a method for correcting the lightness of images.

#### SUMMARY OF THE INVENTION

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According to one aspect of the present invention, the method for correcting lightness of an image includes the steps of: calculating a first scale and a second scale based on an image scale of an original image from image 15 information of the original image; multiscale retinex processing the original image with respect to the first scale and the second scale; and synthesizing a result of the multiscale retinex processing with the image information of the original image.

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In one embodiment of the present invention, the method for correcting lightness of an image further includes the step of correcting the result of the multiscale retinex processing based on a gain correction

value and an offset correction value.

In another embodiment of the present invention, the offset correction value is corrected based on a histogram of a lightness value against the number of pixels of the original image.

In still another embodiment of the present invention, the first scale is a small scale, and the second scale is a large scale.

In still another embodiment of the present invention, a radius of the large scale is about 1/2 of a longer side of the original image.

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In still another embodiment of the present invention, a radius of the small scale is about 1/5 of a longer side of the original image.

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According to another aspect of the present invention, the image processing device includes: a scale size calculating section for calculating a first scale and a second scale based on an image scale of an original image from image information of the original image; and

5 a scale retinex processing section for multiscale retinex processing the original image with respect to the first scale and the second scale, wherein a result of the multiscale retinex processing is synthesized with the image information, thereby generating an output image.

10 In one embodiment of the present invention, the result of the multiscale retinex processing is corrected based on a gain correction value and an offset correction value.

15 In another embodiment of the present invention, the offset correction value is corrected based on a histogram of the lightness value against the number of pixels of the original image.

20 In still another embodiment of the present invention, the first scale is a small scale, and the second scale is a large scale.

In still another embodiment of the present invention, a radius of the large scale is about 1/2 of a longer side of the original image.

In still another embodiment of the present invention, a radius of the small scale is about 1/5 of a longer side of the original image.

5                 Thus, the invention described herein makes possible the advantages of (1) providing a method for correcting the lightness of images, by which an appropriate dynamic range conformable to the size of the images can be obtained, and (2) providing an image 10 processing device using such a correction method.

These and other advantages of the present invention will become apparent to those skilled in the art upon reading and understanding the following detailed 15 description with reference to the accompanying figures.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram showing an exemplary 20 lightness correction device for use in implementation of a method for correcting the lightness of images according to the present invention.

Figure 2 is a flowchart for illustrating an operation of the lightness correction device.

Figure 3A is an exemplary histogram of the 5 lightness value against the number of pixels of the original image, and Figure 3B is an exemplary histogram of the lightness value against the number of pixels with a compressed dynamic range after the retinex processing.

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#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, an embodiment of the present invention will be described with reference to the drawings. Figure 1 is a block diagram showing an exemplary lightness 15 correction device for use in implementation of a method for correcting the lightness of images according to the present invention. Figure 2 is a flowchart for illustrating an operation of the lightness correction device.

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In the lightness correction device shown in Figure 1, when an input image 11 is read into the lightness correction device, the image size of the input image 11 is transmitted to a scale size calculating

section 14 for calculating a scale size of an image. In the scale size calculating section 14, based on the received image size of the input image 11, the scale sizes of the small and large scales are calculated, respectively 5 (see step S1 of Figure 2). In the large scale, a scale size is calculated so that the radius of the large scale is equal to 1/2 of a longer side of the input image. In the small scale, a scale size is calculated so that the radius of the small scale is equal to  $0.4 \times$  (the radius of 10 the large scale), i.e.,  $0.2 \times$  (a longer side of the input image).

However, the radii of the small and large scales are not limited to the values shown above, but may 15 be modified and set to appropriate values in accordance with the quality, size, etc., of an input image.

After the scale sizes of the large and small scales have been calculated in the scale size calculating 20 section 14, these calculated scale sizes are transmitted to a two-scale retinex processing section 12.

On the other hand, image information of the input image 11 is transmitted to a correction value calculating

section 13. In the correction value calculating section 13, a histogram of the lightness value against the number of pixels is generated based on the image information of the input image, and an offset correction 5 value  $A_0$  is calculated based on the histogram (Step S2).

Specifically, a histogram of the lightness value against the number of pixels as shown in Figure 3A is generated based on the image information of the input 10 image. In this histogram, the number of pixels (vertical axis) against the lightness (horizontal axis) is converted into a graph. In this histogram, pixels are counted from a pixel having the smallest lightness up to a pixel having the greatest lightness, and the lightness 15 of the midpoint pixel of these pixels (i.e., a pixel which halves all the pixels into a group of the brighter pixels and a group of the less brighter pixels) is adopted as the offset lightness value  $Y_0$ . Figure 3B is a graph showing the distribution of the lightness with the 20 compressed dynamic range after the retinex processing. That is, the offset lightness value  $Y_0$  is set so that the number of pixels having a lightness value greater than the offset lightness value  $Y_0$  is equal to the number of pixels having a lightness value smaller than the offset

lightness value  $Y_o$ .

Thereafter, in the correction value calculating section 13, an offset correction value  $A_o$  is obtained 5 based on the offset lightness value  $Y_o$  and an average lightness value  $Y_v$  in the quantitized histogram by expression (8):

$$A_o = Y_v + (Y_v - Y_o) / 3 \quad \dots \quad (8)$$

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Herein, the denominator "3" in expression (8) was obtained from experimentation.

15 After the offset correction value  $A_o$  has been obtained in the correction value calculating section 13, the offset correction value  $A_o$  is transmitted to the two-scale retinex processing section 12.

20 In the two-scale retinex processing section 12, based on image information of the input image 11, the single retinex processing is performed with respect to the two types of scale sizes, i.e., the small and large scales, which have been obtained from the scale size calculating section 14 (step S3 and step S4). The

retinex processing with each of the small scale and the large scale is conducted for respective spectrum band components of the input image  $I_1$  similarly to the conventional single retinex processing. In this case,  
5 the surround function is also represented by expression (2). Furthermore, the scalar coefficient  $K$  is set so that the total value of the surround function is 1, i.e.,  $\iint F(x,y) dx dy = 1$  is satisfied.

10 As described above, the single scale retinex processing is performed for the respective scale sizes (small and large scale sizes). Then, the result of the single retinex process for each of the scale sizes is multiplied by a weighting factor  $\omega_n$ , and the multiplication results are totaled, thereby obtaining the result of the multiscale retinex processing,  $R_{MSR1}$ . Thereafter, the result  $R_{MSR1}$  is corrected by expression (6) based on the color correction coefficient  $C_i(x,y)$  represented by expression (5).  
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20 The thus-obtained result of color correction multiscale retinex processing,  $CR_{MSRCR1}(x,y)$ , is corrected by expression (7) based on the offset correction value  $A_0$  calculated in the correction value calculating section 13

and the preset gain correction value  $A_g$ .

As described above, in the two-scale retinex processing section 12, the input image 11 is multiscale retinex processed based on the two types of scales, i.e., the large and small scales, whose scale sizes are each calculated based on the size of the input image 11 in the scale size calculating section 14. The multiscale retinex processed image is extended to conform to an appropriate dynamic range based on the offset correction value  $A_o$  calculated in the correction value calculating section 13 and the preset gain correction value  $A_g$ , and is output as a result of the final color correction multiscale retinex processing,  $I_{MSRCRi}$ .

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Thereafter, the result of the final color correction multiscale retinex processing,  $I_{MSRCRi}$ , output from the two-scale retinex processing section 12 is synthesized with the image information of the input image 11, and output as an output image (Step S5).

20 According to the method for correcting the lightness of images of the present invention, the lightness of an image is corrected based on an original

image and a result of a multiscale retinex processing that is performed on the original image with respect to two types of scale sizes (i.e., with the small and large scales) which are obtained based on the image scale of 5 the original image. Thus, an unsmooth gradation of the image due to the two types of retinex processing results is lessened by the synthesis with the original image, whereby the image deterioration is suppressed, and an appropriate lightness correction processing is performed 10 in accordance with the image size. Furthermore, the memory capacity used for calculation, the number of accesses, and the calculation amount are significantly reduced, whereby the multiscale retinex processing can be quickly performed. Furthermore, the offset 15 correction value used for correcting the result of the multiscale retinex processing is calculated based on the histogram of the lightness value against the number of pixels. Therefore, the correction of the lightness is flexibly performed on the original image.

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Various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the

claims appended hereto be limited to the description as set forth herein, but rather that the claims be broadly construed.